Chemical compositions and minerals of some commercially important fish species from the South Caspian Sea

1Pirestani, S., 1*Ali Sahari, M., 1Barzegar, M. and 2Seyfabadi, S. J.

1Department of Food Technology, College of Agriculture, Tarbiat Modares University, P.O. Box 14115-336 Tehran, Iran
2Department of Fisheries, College of Natural Resources and Marine Science, Tarbiat Modares University P.O. Box 14115-336 Tehran Iran

Abstract: The objective of the current study was determined chemical composition (including protein, lipid, ash and moisture) and content of minerals (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se, K, I and F) in five fish species from the South Caspian Sea. The chemical analysis revealed that the protein content of common kilka, Caspian kutum, common carp, pike perch and golden grey mullet was 18.35%, 21.39%, 19.37%, 20.35% and 21.28% of the fresh weight, respectively. The lipid content and ash ranged from 1.97-10.23%, 1.15-3.33% of the fresh weight, correspondingly. The concentrations of several elements in the fishes were significantly different among the species in each country. Concentration of Cr was the highest in muscle of Caspian kutum. The highest concentrations of Fe, Ca, Na, I and F were found in the common carp among the five species (p<0.01). Phosphorus value was highest in the pike perch, whereas Zn, Mg and P were highest in muscle of the common kilka. Many of the aforementioned indices had significant statistical differences (P≤0.01) and the cluster analysis results of mineral content showed that Caspian kutum and golden grey mullet had good similarity, followed by the pike perch and common carp, respectively; and common kilka had no resemblance with others.

Key words: Chemical composition, mineral, fish species, Caspian Sea

Introduction

Fish is one of the most important sources of animal protein available, and has been widely accepted as a good source of protein and other elements for the maintenance of a healthy body (Arannilewa, 2005). As compared to red meat, fish flesh is easily digestible because it contains long muscle fibers. In addition, fish is a good source of fluorine and iodine required for the development of strong teeth and prevention of goiter in man (Arannilewa, 2005). Moreover, the consumption of fish has been linked to health benefits such as reduced risk of coronary heart disease. A preventive and/or curative effect has also been reported for arterial hypertension (Millar and Waal-Manning, 1992), human breast cancer (Rose and Connoll, 1993), colon and prostate cancer (Marchioli, 2001 and 2002; URL, 2002), inflammatory diseases (Belluzi et al., 1993; James and Cleland, 1996), asthma (Dry and Vincent, 1991; Hodge et al., 1996) and disorders of the immune system (Kenneth, 1986; Levine and Labuza, 1990). In addition, fish oil helps to prevent brain aging and Alzheimer’s disease (Kyle, 1999).

Besides, the Caspian Sea is the largest inland body of water in the word (Anan, 2005). Bony fishes such as Caspian kutum, golden grey mullet, common carp, pike perch and cartilaginous fishes such as common kilka abound in it together with commercially valuable species in the Caspian Sea. Yet, no detailed chemical stud of mineral content and chemical composition of these fishes is available.

Thus this study was carried out to determine chemical compositions (including protein, lipid, ash and moisture) and content of minerals (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se, K, I and F) of five fish species of the South Caspian Sea.
Materials and methods

Fish species

The fish species used for this study were Caspian kutum (Rutilus frisii kutum), golden grey mullet (Liza aurata), common carp (Caprinus carpio), pike perch (Sander lucioperca) and common kilka (Clupeonella cultivating caspia), all purchased (in the same genus, weight and size; November 2006; 25-30 specimens; middle size value) from three different harbors (Figure 1): Anzalii (station 1), Babolsar (station 2) and Torkaman (station 3) located in North of Iran, represented by West, South and East of Southern Caspian Sea, respectively. The weights and lengths of these species were 840±10 g and 62±3 cm, 760±10 g and 48±2 cm, 830±15 g and 40±3 cm, 430±15 g and 30±2 cm, and 60±5 g and 10±2 cm, respectively. On board the fish specimens were beheaded, gutted and the edible sections were selected. The edible sections of each species from each harbor were mixed and transferred to the laboratory 5 hours post-capture on arrival in ice. These were used in the final analyses.

Chemical composition analysis

The proximate analysis was carried out according to the procedures of the Association of Official Analytical Chemists (AOAC, 1990). Moisture was determined by drying the samples in an oven (Memmert-500, Germany) at 105°C to constant weight (Egan et al., 1990); crude ash was determined by incineration in a muffle furnace (Heidolph-3001k, Germany) at 550°C for 10 hours (Egan et al., 1990) and crude protein was determined by the Kjeldahl method (N × 6.25) using an automatic Kjeldahl system (Kjeltac auto, model 1030, Germany) (Egan et al., 1990). Finally, lipid was determined according to the method described by Bligh and Dyer (1959).

Mineral analysis

Concentrations of 12 elements (Zn, Mn, Fe, Cu, Cr, Ca, Na, Mg, Mo, P, Se and K) were measured using ICP (Perkin-Elmer, model Optima 2100DV, Australia) according to the manufacturer’s recommendations (Perkin-Elmer Corp. 1989), while the procedure used for measuring concentration of fluorine (Light and Cappuccino, 1975) and iodine (Egan et al., 1990) has been described previously.

Statistical analysis

The obtained resulting data were presented as mean ± standard deviation (SD) of three separated determinations and given to the analysis of variance (ANOVA). The significant mean was compared by Duncan’s test at α=1 % level using SAS 6.03 (1990) software. Within this analysis various items are grouped or classified in a cluster by their similarities yielded in the data. Cluster analysis was displayed using Ward’s method. The linkage in a dendrogram shows the order of dissimilarity designated as a distance index (Krzanowski, 1995).
Results and discussion

The chemical analysis of samples is presented in Table 1. The identified species contain 1.97-10.23% fat. Based on the fat content, L. aurata, C. carpio and S. lucioperca were distinguished as lean fish, whereby the fat content was lower than 5% by weight (Bennion and Scheule, 2003), while C. cultriventris caspia and R. frisii kutum were classified as fat fish. Feeley et al. (1972) and Osman et al. (2001) reported that low-fat fish species have higher water content and, as a result, their flesh is whiter in color. The crude protein content ranged from 18.35% (C. cultriventris caspia) to 21.39% (R. frisii kutum). Crude ash ranged from 1.15% in C. carpio to 3.33% in C. cultriventris caspia.

Concentrations of 14 elements in the samples of fish species are shown in Table 2. Selenium (Se, 0.04 ± 0.00) and molybdenum (Mo, 0.08 ± 0.00) levels corresponded to each other in the study and nearly similar values were found for all fish species. Selenium is an antioxidant which prevents damage of the cells due to rancidification and delays the pathological ageing process. It inhibits chromosome damage, mutations and cancer. An intake of 70 μg for healthy men and 50 μg for healthy women suffices to keep the kinetics in balance. There are no known diseases which can be directly connected with molybdenum deficiency. Molybdenum is an interesting trace mineral, but it is also one which needs to be investigated more thoroughly. The significance of Mo for health is not very well known. Nevertheless, it is classified as an essential trace element because it is a component of at least three enzymes. Human requirements for Mo are not known in any detail, although the RDAs (Recommended Dietary Allowance) in various countries range from 100 to 500 μg (Tolonen, 1990).

The maximum concentration of chromium (Cr) in fish samples was 0.78 mg/kg. Although chromium Cr is an essential element helping the body to use sugar, protein and fat, at the same time it is carcinogenic for organisms (Institute of Medicine, 2002). Excessive amounts of Cr may cause adverse health effects (ATSDR, 2004). Requirements for Cr are not yet known. According to American estimates, a daily intake of 50-200 μg is a safe and adequate dosage (Tolonen, 1990).

The levels of manganese (Mn) in all samples ranged from 0.12 to 0.17 mg/kg. Daily intake of small amounts of Mn is needed for growth and good health in humans, otherwise deficiency of Mn can cause nervous system problems (Demirezen, 2006). The RDA for Mn is 3.8 mg, and a number of studies have indicated that actual daily intake is closer to 5-6 mg. (Tolonen, 1990).

The average copper (Cu) concentration was 1.02 to 2.6 mg/kg in the samples investigated. Furthermore the highest average concentrations of Cu were observed in C. carpio (2.58 mg/kg). Copper is essential for good health, but very high intakes can cause health problems such as liver and kidney damage (ATSDR, 2004). The RDA for Cu is 2 mg, but, in Finland, for instance, the average daily diet contains 1.7 mg of Cu.

Iron (Fe) level was highest in C. carpio with 12.55 mg/kg. Fish is a major source of Fe for adults and children. Iron deficiency causes anemia (Demirezen, 2006). The average intake of Fe is too low, although many people receive more than 18 mg per day, which is the RDA (Tolonen, 1990).

The results obtained from this study showed that the zinc (Zn) contents of samples were between 3.34 and 16.1 mg/kg. As shown in Table 2, the lowest Zn concentrations were found in S. lucioperca (3.34 mg/kg). Zinc is an essential element in human diet. Too

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Moisture</th>
<th>Crude ash</th>
<th>Crude lipid</th>
<th>Crude Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. frisii kutum</td>
<td>72.4± 0.2</td>
<td>1.3± 0.1</td>
<td>6.7± 0.0</td>
<td>21.4± 0.6</td>
</tr>
<tr>
<td>L. aurata</td>
<td>74.8± 0.1</td>
<td>1.2± 0.0</td>
<td>4.9± 0.0</td>
<td>21.3± 0.2</td>
</tr>
<tr>
<td>C. carpio</td>
<td>77.8± 0.0</td>
<td>1.2± 0.0</td>
<td>3.6± 0.0</td>
<td>19.4± 0.9</td>
</tr>
<tr>
<td>S. lucioperca</td>
<td>77.7± 0.1</td>
<td>1.5± 0.1</td>
<td>2.0± 0.0</td>
<td>20.4± 0.4</td>
</tr>
<tr>
<td>C. cultriventris caspia</td>
<td>70.8± 0.4</td>
<td>3.3± 0.1</td>
<td>10.2± 0.1</td>
<td>18.4± 0.4</td>
</tr>
</tbody>
</table>

Data is expressed as mean ± SD of three separated determinations.

Table 1. Chemical compositions of fish species (% wet weight)
little Zn can cause problems; however, too much Zn is harmful to human health (ATSDR, 2004). Opinions about Zn requirements are widely divergent. The adult RDA for Zn is 15 mg (Tolonen, 1990).

Highest levels of fluorine (F) was found in C. carpio, followed by R. frisii kutum, S. lucioperca, L. aurata and C. cultriventris caspia with 0.36, 0.31, 0.28, 0.18 and 0.14 mg/kg, respectively. The most important function of F is to prevent caries in the teeth. It strengthens the enamel and thus protects the teeth from the attacks of bacteria and acids. Fluoride has also been associated with increased incidence of cardiovascular disease. In the United States the RDA for F is 1.5-4 mg for healthy adults. Some researchers maintain that 4 mg should be the absolute maximum dosage (Tolonen, 1990).

Iodine (I) levels were also significantly highest in C. carpio, with an average value of 1.77 mg/kg. Iodine plays a role in the regulation of the thyroid gland activity. The RDA for I is 100-200 μg per day (Tolonen, 1990).

The results obtained from this study showed that the phosphorous (P) and magnesium (Mg) contents of samples were 1077.27-3184.77 and 148.77-333 mg/kg, respectively. The highest average concentrations of P and Mg were observed in C. cultriventris caspia. Magnesium is an essential mineral for cell function and it occupies a key role in all reactions with phosphate. The cells also require Mg for cell division and enzyme production. The RDA for P and Mg is 300-450 and 2000 mg per day, respectively (Tolonen, 1990).

The levels of potassium (K) and sodium (Na) in all samples ranged from 1809.06-2678.36 mg/kg and 488.17-786 mg/kg, respectively. Potassium is required for the normal functioning of the nerves and muscle, the sugar metabolism, acid-base balance and oxygen metabolism in the brain. The heart also needs potassium. Sodium regulates the electrolyte and acid-alkali balances, the conductive capacity of the nerves, muscle contractions and the production of adrenaline and amino acids. The human sodium requirement is about 3 g per day. Most people have a K intake of between 2-4 g per day on average (Tolonen, 1990).

The concentrations of several elements in the fishes were significantly different among the species in each country. Concentration of Cr was the highest in muscle of R. frisii kutum. The highest concentrations of Fe, Ca, Na, I and F were found in the C. carpio among the five species (p<0.01). Phosphorus value was highest in the S. lucioperca, whereas Zn, Mg and P were highest in muscle of the C. cultriventris caspia.

According to Esmailzadeh Kenari et al. (2004) report the levels of P and Ca in R. frisii kutum were 267.8 – 269.9 and 84.58 – 93 mg/100g, respectively.

| Table 2. Mineral compositions of fish species given as mg/kg dry weight |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Ca | 275 ± 7 d | 274 ± 13 d | 966 ± 36 a | 635 ± 10 c | 828 ± 9 b | 1500.0 mg |
| Mn | 0.16 ± 0.03 a | 0.12 ± 0.01 a | 0.17 ± 0.01 a | 0.17 ± 0.05 a | 0.14 ± 0.03 a | 6.1 mg |
| Mg | 244 ± 4 c | 206 ± 4 d | 276 ± 6 b | 149 ± 3 e | 333 ± 4 a | 440.0 mg |
| Fe | 4.49 ± 0.17 c | 6.16 ± 0.10 b | 12.55 ± 0.21 a | 4.18 ± 0.10 c | 4.60 ± 0.29 c | 19.0 mg |
| Zn | 5.46 ± 0.36 c | 7.66 ± 0.35 b | 7.44 ± 0.30 b | 3.34 ± 0.56 d | 17.23 ± 0.98 a | 16.0 mg |
| Cu | 2.36 ± 0.14 a | 1.10 ± 0.07 c | 2.58 ± 0.14 a | 2.48 ± 0.18 a | 1.75 ± 0.08 b | 1.7 mg |
| Cr | 0.78 ± 0.06 a | 0.16 ± 0.01 c | 0.74 ± 0.03 ab | 0.67 ± 0.03 b | 0.11 ± 0.04 c | 29.0 μg |
| F | 0.31 ± 0.03 a | 0.18 ± 0.04 b | 0.36 ± 0.04 a | 0.28 ± 0.02 a | 0.14 ± 0.02 b | 250.0 μg |
| Mo | 0.08 ± 0.00 a | 0.08 ± 0.00 a | 0.08 ± 0.00 a | 0.08 ± 0.00 a | 0.08 ± 0.00 a | 120.0 μg |
| Se | 0.04 ± 0.00 a | 0.04 ± 0.00 a | 0.04 ± 0.00 a | 0.04 ± 0.00 a | 0.04 ± 0.00 a | 30.0 μg |
| I | 1.17 ± 0.25 bc | 0.73 ± 0.15 c | 1.77 ± 0.15 a | 1.57 ± 0.21 ab | 0.80 ± 0.20 c | - |
| Na | 488.17 ± 10 d | 650 ± 5 c | 786 ± 7 a | 486 ± 10 d | 679 ± 10 b | 17.0 g |
| K | 2174 ± 90 c | 2201 ± 75 c | 2388 ± 41 b | 2678 ± 36 a | 1809 ± 24 d | 4500.0 mg |
| P | 1249 ± 182 bc | 1457 ± 2 c | 2012 ± 2 b | 1077 ± 60 d | 3185 ± 7 a | 2000.0 mg |

Data is expressed as mean ± SD of three separated determinations

** Value in the same columns with different superscript letters within a same strain are significantly different (p<0.01)
This may be because of different analytical methods being used or that analytical data was obtained from other sample lots. Based on our literature studies, there were no information on the amount of other elements in fish and, therefore, we could not compare our results with those of other studies. The result of the cluster analysis is shown in Figure 2. The dendrogram was classified into groups by arbitrarily applying a rescaled distance cluster Ward’s method. The cluster analysis results showed that the R. frisii kutum and L. aurata had good similarity, followed by the S. lucioperca and C. carpio, respectively. In addition, C. cultriventris caspia had no similarity with other species.

References


ATSDR. 2004. Agency for Toxic Substances and Disease Registry, Division of Toxicology, Clifton Road, NE, Atlanta, GA. Available from http://www.atsdr.cdc.gov/toxprofiles/.


Esmailzadeh Kenari, R., Sahari, M. A. and Motamedzadegan, A. 2004. Comparative study on nutrient of kutum (Rutilus frisii kutum) and grass carp (Ctenopharyngodon idella) and their marinade qualities. 2nd International Congress on Aquaculture, Fisheries Technology and Environmental Management. Athens, Greece, E.U.


Kyle, D. J. 1999. Low serum docosahexaenoic acid is a significant risk factor for Alzheimer’s dimension. Lipids 34: S245.


